Palaeontological Heritage Preliminary Study for Bulk Water Pipeline from Glenn Melville Dam to Eastern Cape Coastal Towns

Prepared for: BESC

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Contents:

Stratigraphy

Stratigraphy is the sequence of rock layers, from the lowest (oldest) to the highest (youngest). Conformably deposited rocks are ones which are continually deposited, layer upon layer, with only limited periods of disruption or erosion between them.

The chief stratigraphy of the area spans the upper portion of the Cape Supergroup, and the lowest portion of the Karoo Supergroup. The Cape Supergroup is comprised of sediments deposited along the northern edge of the semi-enclosed Agulhas Sea, which opened in response to early rifting between South America, Africa and Antarctica. The Karoo strata were deposited in the Karoo basin, which resulted from shortening and thickening of the southern margin of Africa, with coeval folding and uplift of the Cape Supergroup strata along its southern margin.

The Cape Supergroup is subdivided, from bottom to top, into the Table Mountain Group, the Bokkeveld Group and the Witteberg Group. Of these only the Witteberg Group outcrops along the Phase 1 route. The Karoo Supergroup begins with the Dwyka Group and the Ecca Group, which are represented in the study area.

The Witteberg Group is divided into the (lower) Weltevrede Subgroup and the (upper) Lake Menz Subgroup. Weltevrede Subgroup strata are exposed throughout most of the lower lying coastal area, and northwards to the Mountain Drive escarpment.

The Lake Menz Subgroup consists of four subunits (the Witpoort, Kweekvlei, Floriskraal and Waaipoort formations), and underlies most of the Grahamstown peneplane, from the Mountain Drive Ridge to a point beyond Botha's Hill.

North of this the Dwyka Group defines the landscape until Ecca Pass is reached. Dwyka strata also overlie the Witteberg Group in the vicinity of Grahamstown, where folding has pushed them down below the level of adjacent Witteberg strata.

Far more recent limestones unconformably overlie some of the strata along the coastal plane.

Furthermore, deep weathering and chemical alteration of strata underlying the ancient plain between Grahamstown and Botha's Spruit have entirely altered them to some considerable depth. Softer rocks are leached to a white chalky clay, which is capped across the ancient planar surface by a tan coloured microcrystalline silcrete comprised of much of the silica, iron and magnesium that were once contained in the underlying strata.

Age, Origin and Palaeontology of strata

Most of South Africa's known Devonian plant fossils come from shales within the Upper Devonian age lower Witteberg Group in the Eastern Cape. The lower Witteberg consists of shoreface derived quartzitic sandstones, with occasional shaly units associated with river mouths. Plant fossils within these shales were first noted by Bain in 1857, who came across various plant fossils during road building activities in the vicinity of Kowie River (*Port Alfred*), Woest's Hill and Howison's Poort.

His original material has been lost; however, with ongoing development at the Kowie River Mouth later in the eighteen hundreds, further Weltevrede Formation plant fossils were uncovered. These were mainly discovered when the cliffs behind the hospital and the station were cut back, and provided the material for the definition of a few taxa. Associated with the plant fossils were chonchostracan arthropods and eurypterid fragments. Only very cursory collecting, however, is evinced by the museum collection. Other Weltevrede Formation plant fossils were found on a farm (Sweet fountain) near Bathurst.

It is almost certain that the Woest's Hill site of Bain was also within the (Upper Devonian, Frasnian aged) Weltevrede Formation.

The Howison's Poort locality may still be located. It is sited about fifteen metres above the bottom of the (Upper Devonian, Famennian aged) Witpoort Formation sequence and consists of a black shale less than a metre thick within a cliff of quartz rich sandstones. Various researchers have subsequently recovered plant fragments from pieces of shale that can, with difficulty, be winkled out of the cliff. A number of taxa have been described. Until the 1980s this remained essentially the only known fossil locality within the Witpoort Formation.

Interception of a relatively thick black shale near the top of the Witpoort Formation during roadworks at Waterloo Farm near Grahamstown in 1985 engendered the discovery of sub-saharan Africa's most important Late Devonian fossil site. This site is of particular international interest, not just due to its comprehensive preservation of a fauna and flora, but also because it belongs to the latest Famennian age, immediately preceding the world-changing second great extinction event. This was an important time period when enormous environmental upheavals were triggered by the emergence of the first forests, whole groups of organisms went entirely extinct and the earliest tetrapods emerged from the water to exploit the first widespread terrestrial environments.

Research on the Waterloo Farm fossils is ongoing; however, a fauna of about 20 species of fossil fish has been isolated, of which about a third have thus far been taxonomically defined. Some of these, such as the world's oldest fossil lamprey,

Priscomyzon riniensis, have caused an international stir. *Priscomyzon* provides an example of the unusual type of preservation at Waterloo Farm, where impressions of soft tissues, rather than just bones, are recorded. The fauna also contains a range of armour plated (placoderm) fish, spine finned (acanthodian) fish, ancient sharks, early ray-finned fish, and lobe-finned fish including coelacanths. These are accompanied by arthropods such as scorpions and giant euryperids ('water- scorpions'), in addition to one of the world's most significant records of algae and plants from the latest Devonian.

The upper remainder of the Lake Menz subgroup, the Kweekvlei Formation, Floriskraal Formation and Waaipoort Formation are all Early Carboniferous in age, the 360 myo Devonian-Carboniferous boundary (and the Hangenberg Extinction event) having been passed at the top of the Witpoort Formation.

A sudden, basin-wide subsidence terminated the sandy shoreline deposition of the Witpoort Formation, which is overlain by fine muddy sediments of the Kweekvlei Formation. These sediments become increasingly silty upwards but have, as yet, yielded only plant fragments.

As the basin gradually shallowed delta front and shoreline sands of the Flouriskraal Formation encroached on the underlying silts and muds of the Kweekvlei Formation.

Flouriskraal strata are in turn overlain by the Waaipoort mud- and siltstone unit. This represents a lagoonal to mud-flat environment behind and adjoining the prograding Floriskraal shoreline sands. Further to the west of the study area, from near Port Elizabeth towards the Western Cape, thin carbon-bearing lenses have been discovered within the Waaipoort Formation, from which interesting, though scarce, plant fossils have been described. More significantly a fish fauna consisting largely of primitive palaeoniscoids has been described, chiefly from an intensely rich lens discovered near Lake Menz. Some shark material and a giant eurypterid have also been found, however, consistent with the global situation, no placoderm fish are found above the Devonian-Carboniferous boundary (i.e. above the Witpoort Formation).

Above the Waaipoort Formation of the Witteberg Group (uppermost Cape Supergroup), after an unconformity (gap in the geological record) the Dwyka Group (lowermost Karroo Supergroup) is encountered. Deposition had now shifted from the northern edge of the Agulhas Sea to the increasingly freshwater, inland Karoo Basin. This Dwyka Group (particularly here in the south of the basin) consists almost exclusively of a diamictite known as the Dwyka tillite. This is a distinctive rock type which, when freshly exposed, consists of a hard fine-grained blueish-black matrix in which abundant roughly shaped clasts are embedded. These vary greatly in both lithology and size. During the formation of the Dwyka, beginning in the Late Carboniferous, southern Africa had drifted over the south pole, whilst simultaneously; the world was experiencing a cold episode. Glaciers flowing into the flooded Karoo basin broke up, melted and discharged a mixture of finely ground rock flour and rough chunks of rock. These formed the matrix and clasts of the Dwyka tillite.

Early in the Permian period the ice sheets retreated and fine muds were washed into the Karoo Basin, forming the Prince Alfred and Whitehill formations of the lower Ecca Group which interfinger, at first, with the last tillites.

Probably due to the lack of good outcrop in the Eastern Cape, fossils are not locally known from the Whitehill formation. In other parts of the country it has, however yielded some exquisite fossils. These include Africa's earliest known reptile, the aquatic *Mesosaurus*, early crustaceans, and scarce but beautifully preserved ray-finned fish.

Plant fossils have been discovered along the cuttings of Ecca Pass, which is the type locality of the Ecca Group. These belong to the earliest appearance of the *Glossopteris* fauna – named after *Glossopteris*, an early genus of seed plant that may ultimately have included the ancestors of flowering plants. Fish trails have also been found in the vicinity of the Ecca Pass, underlying the potential that fish fossils could potentially also be recovered from this horizon.

More than 200 million years elapsed before the deposition of the next youngest strata, generally during the Miocene to Pliocene. These consist of limestone deposited on the coastal shelf carved from the Witteberg sediments during the Cretaceous. They contain marine invertebrates and a famous locality near Birbury farm in the Bathurst district yields thousands of fossil shark's teeth.

Investigation of pipeline route and reservoir positions.

The James Kleynhans Water Treatment Works is situated in a valley weathered into less resistant shales of the Ecca Group. Between the dam and the treatment plant the shales are largely covered with recent alluvium. Close to the plant there is a small amount of shale outcrop, which, however, is extremely weathered, breaking into the long thin shards that give this type of weathering the name, 'pencil weathering'. Fossil sampling was therefore precluded. These are laterally equivalent, however, to shales those alongside the R67, which have yielded abundant fish trails.

Similar pencil weathered shales are evident alongside the route as far as RE/19. Here the land rises in response to a lithological change towards more sandy, resistant (stratigraphically underlying), highly crystalline greywackes. These rocks, best seen in a disused stone quarry a little to the east of the pipeline route have a north easterly dip, and a thin dark coloured shale interbed is visible.

This is stratigraphically underlain to the north by shaly units, better visible, in the road cutting nearby. These contain plant fragments, though at this locality they are generally somewhat poor. Going northwards (lower in the succession) these shales are interbedded with layers containing volcanic ash.

Just before the pipeline intercepts the R67 at the top it intercepts the Whitehill Formation (White Band), near the base of the Ecca Group. As discussed above, this unit has in other parts of the country produced important crustacean, fish and early reptile remains though locally the limited outcrop has proved disappointing.

During this survey a small quarry (in the White Band) between the pipeline route and the R67 was investigated. Arthropod and other invertebrate trackways, as well as plant fragment fossils were observed. Excavations in this area should be carefully monitored.

Pic 1. (arthropod trackway observed in the quarry at the top of Ecca Pass)

Crossing the R67, the pipeline route crosses Prince Alfred Formation and encounters the Dwyka tillite horizon, which constitutes the bedrock till about two thirds of the distance across 3/241. It is extremely unlikely that any palaeontological material will be situated along this section of pipeline.

Thereafter the pipeline continues to cut ever stratigraphically lower strata, as it descends into a valley carved from shales of the Witteberg Group upper Lake Menz subgroup. Small outcrops of cream and pinkish shale were discovered in conjunction with thin sandy units. There is a moderate chance that significant fossils could be uncovered here.

The landscape rises to a ridge composed of resilient Witpoort Formation (lower Lake Menz subgroup) quartzite, midway across RE/241. Although the presence of fossiliferous interbedded shales within the quartzite cannot be excluded, the weathered state of this ridge (Botha's Hill) is likely to preclude the disturbance of useful material. It is here that reservoir 1 is to be sited.

Across the Botha's Spruit, to the west, the stratigaphy reverses due to the Grahamstown Syncline, a downward fold in the rock layers, formed during the Cape Folding Event. During the Cretaceous, however, the land to the west of Botha's Hill, composed of upper Lake Menz subgroup shales and Dwyka tillite were weathered to form a flat, poorly drained platform, the Grahamstown Peneplane. Here the shales and tillite are deeply weathered to form a leached white kaolinite clay below, and a tan brown silcrete hardpan crust. No fresh rock and therefore no fossils are therefore likely to be uncovered anywhere between Botha's Hill and the point where the pipeline leaves the peneplane, descending into Belmond Valley at the northern boundary of RE/323. At this point, however, only unfossiliferous Dwyka Tillite is encountered.

The stratigraphically highest shales of the Witteberg Group (Waaipoort Formation, upper Lake Menz subgroup) are deeply buried below the thick soily alluvium of the Belmond Valley floor.

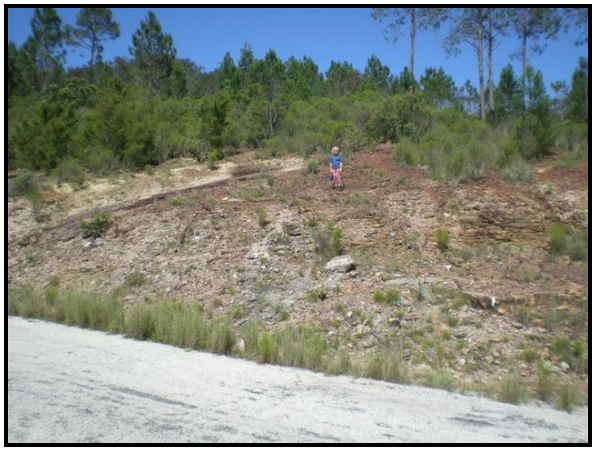
The pipeline encounters the more resistant (stratigraphically lower) Floriskraal Formation as it rises eastward from the valley floor at 24/316, followed by the (stratigraphically even lower) Kweekvlei Formation shale as it passes 1/319 and RE/319. There is a moderate chance that plant or fish fossils could be disturbed here.

Skirting 318 the pipeline crosses the upper boundary of the Witpoort Formation. Here it is laterally equivalent to the internationally important shales at Waterloo Farm, about a kilometre distant. Excavation of any fossiliferous shale here could be very important and excavations here should be carefully monitored.

Reservoir 2 is situated on a weathered ridge well within the Witpoort Formation quartzite and is unlikely to disturb any palaeontological material

As the route descends Woest Hill Pass it continues its stratigraphic descent through fairly massive quartzites. After 1.8 kilometres the quartzites end and there is an abrupt change to the reddish and buff coloured finely interbedded shales of underlying Weltevrede Formation. These exhibit bioturbation and small silvery flakes of plant matter. After a further 0.3 kilometres a prominent maroon shale is encountered in which larger plant fragments were observed and a small fossil lamellibranch shell was discovered. This is significant as it may be the lost site reported by Bain in the 1850s and is probably stratigraphically equivalent to a lost site in the lower part of

Howisonspoort. Excavation in the roadbed immediately adjacent to this site is certain to intercept this layer and a consultant should be present during the work.



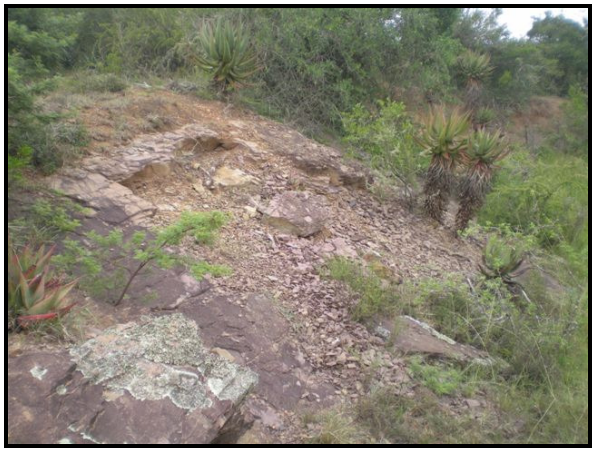
Pic 2. Fossiliferous maroon shale 2.1 kilometres down Woest Hill

Indication of further potentially fossiliferous shales were found at intervals down the pass and as the pipeline rises from the valley bottom at its foot.

Leaving the valley bottom the pipeline rises to the ridge on which reservoir R4 is situated. This flattish topped ridge is capped by a horizontal layer of extremely resilient Quartzite which has at some time, in this vicinity, been quarried for stone in a large number of places. It is extremely unlikely that any palaeontological heritage would be disturbed anywhere along this ridge.

The route follows the above mentioned ridge top for many kilometres, until, around the confluence of 1/293, 1/294 and RE/294 it descends into a small valley.

Shales are exposed in the sides of this valley and, just to the north of the Glenfillan Farm turnoff, a small quarry to the west of the road was found to contain fossil plant material including portions of lycopod stems of the *Haplostigma* type, flattened thallae and larger stem fragments. These are preserved in brown to reddy purplish sandy shales. The fossiliferous outcrop could be further traced to rocks exposed in the roadbed of the turnoff itself. Although nothing particularly remarkable was found on surface, disturbance of fresh rock in this vicinity would have a relatively high chance of exposing fossils of scientific interest.



Pic 3. Small quarry with plant fossils, N.W of the Glenfillan Farm turnoff.

Pic 4. Fossil plant fragments from the roadside quarry N.W. of Glenfillan Farm turnoff

Pic5. Fossil plant stem in the roadbed of the Glenfillan Farm turnoff

Approximately adjacent to the following eastward turnoff (which cuts across RE/294), the route returns to the flat quartzitic spur top, that is often soil capped and is unlikely to prove to be of palaeontological interest.

Thus it continues as far as the site for reservoir 5. This site is overgrown with thick grass, pines and other trees. It is however assumed to be underlain by soil topped quartzite and therefore is unlikely to have much palaeontological potential.

South easterly from the site of reservoir 5 there is very little outcrop to support a proper survey and it cannot be predicted whether or not the soil cover is deeper than the proposed pipeline trench or not. Beyond the D1960 pipeline turnoff, however, the landform suggests the beginning of Alexandria Formation limestones, increasingly capping the underlying geology. These limestones have a moderate to low chance of containing fossils of interest.

Reservoir R6 is sited on a limestone capped hill.

As the pipeline continues east alongside the R72 there is, once more, little outcrop for study, though it is clear that weathered limestone here overlies weathered Weltevrede Formation rock, which is unlikely to be of interest

The pipeline descents through quartzitic rocks to the Kowie River Valley floor, which is deeply buried in alluvium.

One area, which is potentially significant, is the point where the pipeline rises out of the Kowie River Valley to the east. Here it passes fairly close to the old Railway Station. The cut cliffs behind the station were the source of most described Weltevrede Formation fossils, which were discovered in the late eighteen and early nineteen hundreds, preserved in interbedded black shale, both here and across the valley behind the hospital. The sites from which they were recovered have subsequently been lost to the elements. There is, however, a chance that similar, laterally equivalent, shales could be uncovered during the excavation of the pipeline. This could be very significant.

From Port Alfred north to the final reservoir site (R12), very little outcrop was found, however, it may be assumed that a fairly thick layer of soil overlies a badly weathered Weltevrede Formation basement, capped in places by a thin veneer of Alexandria Formation limestone. There is a low chance of any significant palaeontological material being found along this route, or at the site of reservoir R12.

Comments and recommendations

The strata underlying the study area represent important times in the early history of life. These include the uplift of the Agulhas Sea, the opening of the Karoo Basin, the Hangenberg/second global extinction event, the advent of gymnosperm plants, the development of flying insects, and the emergence of terrestrial vertebrates.

Palaeontological endeavours over the past 200 years have been most limited by the moist climate, which leads to deep weathering of the underlying bedrock. As most fossils are preserved in shales and mudstones, and as these are the most prone to deep chemical weathering, there is an extreme paucity of suitable outcrop. It is not therefore surprising that the vast majority of discoveries within the area have resulted from the opening of quarries and the activities of road builders.

The opening therefore of a deep trench from the Ecca through to the lower Witteberg should therefore be seen as an opportunity, for the advancement of heritage research that should not be missed.

It is possible to divide the pipeline route into 3 categories.

1. **High Potential Hotspots**

2. **Areas of Moderate Potential**

3. **Areas of Negligible Potential**

It is recommended that the go-ahead for this pipeline includes heritage related conditions that should that should form a part of the Environmental Management Plan (EMP) for the project execution phase.

Where **High Potential Hotspots** are to be intercepted, the excavation of the pipeline trench should be monitored by an on-site palaeontologist. He should be afforded the opportunity to fully sample any important material, and to recommend that, for example, fossil bearing rock is put to one side, or alternately that a small opening is excavated and left open adjacent to the pipeline.

Where **Areas of Moderate Potential** are traversed, the trench should be inspected section by section, between excavation and infilling, by a palaeontologist, to collect samples or establish the presence of unanticipated horizons of high significance. Such discoveries should then be treated in the manner of High Potential Hotspots.

In **Areas of Negligible Potential** the site engineer should, having been primed, keep an eye out for the unexpected and inform the palaeontologist of any potentially significant occurrences.

High Potential Hotspots include:

1. from where the pipeline encounters the White Hill Formation, before it first encounters the R67 (at the top of Ecca Pass) to the base of the Dwyka Group on the other side of the R67.

2. its intersection with the Devonian/Carboniferous boundary and allied Hangenberg event strata, as it approaches and crosses the Grahamstown-Bathurst Road above Faire Wood.

3. where it encounters the maroon fossiliferous shale approximately 2.1 kilometres down Woest Hill pass

4. where it passes through the reddish shale in the vicinity of the Glenfillan Farm turnoff

5. where it traverses the steep quartzitic terrain entering the Kowie River valley

and

6. where it is excavated through the steep quartzitic terrain on leaving the Kowie River valley.

Areas of Moderate Potential includes:

1. from the James Kleynhans water treatment works to the R67.

2. from the end of the Dwyka tillite (half way across 3/241) to Botha's Hill (Reservoir R1)

3. from where it leaves Belmond Valley (at the boundary of 24/313) to Reservoir R4

4. where it passes through the valley in the vicinity of the confluences of 1/293, 1/294 and RE/294

and

5. from reservoir R6 to the R72 highway.

Areas of Negligible Potential include:

1. where it crosses tillites on 227 and the first half of 3/241

2. from Botha's Hill (Reservoir R1) to the west side of Belmond Valley (at the boundary of 24/316)

4. from Reservoir R4 to the valley beginning on 1/293

5. from 2/293 till Reservoir R6

6. alongside the R72 till the outskirts of Port Alfred

7. the Kowie River floodplain

and

8. from Port Alfred to Reservoir R12

Good channels of communication will have to be maintained between the engineers, contractees and palaeontologist to facilitate the best timing for inspections.